per second and in miles per hour, is derived from the anticyclonic components of Table 9, and the cyclonic components of Table 10, by taking the arithmetical mean of the I-areas (1–4), the II-areas (5–12), and the III-areas (13–20). These means give the average value of the motion, though we, of course, depart from the perfectly natural condition by the summation. Thus in the anticyclonic areas for the radial component u_2 there is an inflow at the top of I-areas, and an outflow at the bottom; and a gentle outflow in the II-areas and III-areas from the top to the bottom. Also compare fig. 10, where the results of Table 11 are plotted. The tangential component v_2 is stronger throughout the middle strata than in those which are higher or lower, but it is much more vigorous in the III-areas than in the I-areas especially at the 3,000-meter level. In the cyclonic areas the radial component u_2 increases generally from the III-area to the I-area. There is a little irregularity in the changes of this component probably due to imperfections in my vector system. The tangential component v_2 increases rapidly from the III-areas to the I-areas, and remarkably so at the 3,000-meter level.

TABLE 11.—*Mean components on I, II, III circles.*

ANTICYCLONIC COMPONENTS.

Distance from center.	I. 250 kilometers.		II. 750 kilometers.		III. 1,250 kilometers.	
Meters per second.	u_2	v_2	u_2	v_2	u_2	v_2
H=10,000	− 3.8	− 3.0	+ 1.9	− 7.0	+ 2.0	− 8.0
7,500	− 1.5	− 6.0	+ 0.1	− 8.4	0.0	− 8.8
5,000	− 1.5	− 8.0	+ 1.3	− 8.1	+ 1.4	− 9.4
3,000	+ 1.5	− 7.5	+ 1.0	− 9.0	+ 1.4	−10.6
1,000	+ 4.0	− 6.5	+ 3.1	− 8.1	+ 3.0	− 9.5
0	+ 3.0	− 3.8	+ 2.5	− 5.4	+ 2.5	− 5.6

CYCLONIC COMPONENTS.

Distance from center.	I. u_2	I. v_2	II. u_2	II. v_2	III. u_2	III. v_2
H=10,000	− 3.5	+ 5.5	− 2.9	+ 8.6	− 1.5	+ 6.5
7,500	− 3.0	+ 9.0	− 3.9	+ 8.9	− 1.0	+ 6.6
5,000	− 4.5	+14.0	− 1.9	+11.8	− 1.5	+ 7.3
3,000	− 3.5	+15.0	− 2.4	+13.5	− 1.0	+ 9.0
1,000	− 6.0	+ 9.5	− 3.5	+ 9.3	− 2.9	+ 6.8
0	− 4.0	+ 6.5	− 3.3	+ 5.5	− 3.3	+ 4.9

ANTICYCLONIC COMPONENTS.

Distance from center.	I. 155 miles.		II. 466 miles.		III. 777 miles.	
Miles per hour.	u_2	v_2	u_2	v_2	u_2	v_2
H=10,000	− 8.5	− 8.7	+ 4.3	−15.7	+ 4.5	−17.9
7,500	− 3.4	−13.4	+ 0.2	−18.8	0.0	−19.7
5,000	− 3.4	−17.9	+ 2.9	−18.1	+ 3.1	−21.0
3,000	+ 3.4	−16.8	+ 2.2	−20.1	+ 3.1	−23.7
1,000	+ 8.9	−14.5	+ 6.9	−18.1	+ 6.7	−21.3
0	+ 6.7	− 8.5	+ 5.6	−12.1	+ 5.6	−12.5

CYCLONIC COMPONENTS.

Distance from center.	I. u_2	I. v_2	II. u_2	II. v_2	III. u_2	III. v_2
H=10,000	− 7.8	+12.3	− 6.5	+19.2	− 3.4	+14.5
7,500	− 6.7	+20.1	− 8.7	+19.9	− 2.2	+14.8
5,000	−10.1	+31.3	− 4.3	+26.4	− 3.4	+16.3
3,000	− 7.8	+33.6	− 5.4	+30.2	− 2.2	+20.1
1,000	−13.4	+32.4	− 7.8	+20.8	− 6.5	+15.2
0	− 8.9	+14.5	− 7.4	+12.3	− 7.4	+11.0

It has been taught in the common expositions of the canal theory of the general circulation that there exists in middle latitudes a strong northward component in the upper strata, a strong southward component in the surface and lower strata, and a powerful eastward component in all strata, increasing from the ground upward. It can be seen by inspecting figs. 6 and 7 that while there is everywhere a general eastward drift, there are certain subareas over which especially a northward component prevails, and others over which there is a southward component. In order to find the maximum meridional components it is expedient to select the following areas for the northward component: Low (16, 8, 2, 7, 15, 6, 14) and High (18, 10, 11, 19, 12, 20), and for the southward component High (16, 8, 2, 7, 15, 6, 14) and Low (18, 10, 4, 11, 19, 12, 20). The values of u_1, v_1 are taken for these areas from Tables 9 and 10, and the mean of them is given in Table 12, Northward and southward velocities in selected areas. It can be seen at once that the general canal theory is by no means supported by the observations. The fact seems to be that between the high and low centers, west of the high and east of the low, there is a northward current in all levels, strongest at about the 3,000-meter level, while east of the high and west of the low there is a southward current also strongest in the

TABLE 12.—*Northward and southward velocities in selected areas.*

Height of the stratum.	Northward. L. 16, 8, 2, 7, 15, 6, 14. H. 18, 10, 4, 11, 19, 12, 20.		Southward. H. 16, 8, 2, 7, 15, 6, 14. L. 18, 10, 4, 11, 19, 12, 20.	
	u_1	v_1	u_1	v_1
10,000	− 6.4	+34.5	+ 4.4	+37.7
7,500	− 8.4	+31.9	+ 5.8	+36.2
5,000	− 9.1	+25.2	+ 8.1	+27.6
3,000	−10.3	+19.7	+10.6	+22.7
1,000	− 9.2	+ 7.9	+ 8.4	+11.7
Surface	− 5.2	+ 2.6	+ 5.3	+ 6.9

Compare Table 124, International Cloud Report, p. 606.

same level. The interchange of air between the pole and the Tropics appears, therefore, to be brought about by alternate currents in middle latitudes flowing past each other on the same levels, and not over each other at entirely different levels, as the canal theory requires. The thermal equilibrium of the air is, therefore, restored through the anticyclonic and cyclonic mechanism, and not by the overflowing currents from the Tropics to the poles and underflowing currents from the poles to the Tropics, as commonly taught. This profoundly modifies the canal theory of the general circulation of the atmosphere and introduces us to a new point of view. The discussion of the theories of the circulation of the air as explained by Ferrel, Oberbeck, and other meteorologists must be taken up next in order, and their views contrasted with the results of our observations.

FOG AND FROST FORMATION.

By DAVID CUTHBERTSON, Local Forecast Official.

An unusually dense fog, such as had not been observed for many years, occurred at Buffalo, N. Y., during the night of February 15 to 16, 1902. It was so remarkable for its great density and for the beautiful frostwork which formed on all sides of trees and other objects that it was a very common topic of conversation for days, and the local Weather Bureau office was called upon, editorially, for explanation of the phenomenon.

South to southwest of Buffalo is Lake Erie, while the Niagara River runs along the entire west side of the city. Lake Erie, for a distance of about two miles from the source of Niagara River, and the river itself, were free from ice. The temperature of the water in the river was 34° F. and the current had a velocity of about 8 miles per hour.

The conditions of the meteorological elements concerned in the phenomenon, as observed at the Weather Bureau station on the night in question, are shown in the following table:

	P. M., February 15.					A. M., February 16.									
	8.	9.	10.	11.	12.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Wind direction	w.	w.	se.	s.	s.	s.	sw.	sw.	sw.	sw.	sw.	sw.	sw.	sw.	sw.
Wind movement	2	2	1	3	1	3	3	2	3	3	3	3	4.	3	5
Air temperature	20	19	17	16	15	14	13	12	13	12	11	10	8	8	11
Relative humidity, per cent	73	....	....	....	....	....	....	....	....	....	....	....	91	....	....
Dew-point, degrees	13	....	....	....	....	....	....	....	....	....	....	....	6	....	....

Dry and wet bulb thermometer readings taken over the water would have been interesting, but it is clear from the data at hand that, since the water of both lake and river was 14° or more warmer than the air, heat radiating from the water warmed the quiet, superincumbent air and greatly increased its capacity for water vapor. At the same time evaporation from the water surface nearly saturated this quiet, warm air; convectional currents mixed it with the colder layers above, thereby cooling it below its dew-point and condensing much of its vapor into fog particles. After the air had been well saturated with aqueous vapor, the wind slowly carried it over the city, where still further cooling caused more condensation and produced denser fog. The steady and rather rapid fall in temperature from 20° at 8 p. m. to 8° at 8 a. m. materially aided the formation.

As far as can be learned, the fog at its greatest density extended a distance of about five miles east of the Niagara River, while in a condition of less density it doubtless extended considerably beyond that limit.

The frostwork on trees and other objects had a thickness of one-eighth inch or more and was quite evenly distributed over their entire surfaces. Ordinarily we find hoarfrost on but one side of objects, but in this case its deposit on all sides was evidently due to the very sluggish air movement.

Fogs like that of February 15–16 are very rare in this locality, owing to the usually rapid movement of the air, especially from the directions in which the lake and river lie.

HAWAIIAN CLIMATOLOGICAL DATA.

By CURTIS J. LYONS, Territorial Meteorologist.

GENERAL SUMMARY FOR MARCH, 1902.

The level of water in the artesian well rose during the month from 33.80 to 34.05 feet above mean sea level. April 1, 1901, it stood at 34.30. The average daily mean sea level for the month was 9.85 feet on the scale, 10.00 representing the assumed annual mean.

Trade wind days, 23 (1 of north-northeast); normal, 18; average force of wind (during daylight), Beaufort scale, 3.0; cloudiness, tenths of sky, 6.0; normal, tenths of sky, 4.6.

Approximate percentages of district rainfall as compared with normal: Hilo, 420; Hamakua, 520; Kohala, 480; Waimea, 530; Kona, 300; Kau, 200; Puna, 700; Olaa, 300; Maui, 300 to 500; Oahu, 300; Kauai, 380.

Mean temperatures: Pepeekeo, Hilo district, 100 feet elevation, average maximum, 73.7°; average minimum, 66.4°; Waimea, Hawaii, 2,730 elevation, 73.5° and 60.2°; Kohala, 521 elevation, 73.4° and 64.0°; Waiakea, Kula, Maui, 2,700 elevation, 74.2° and 57.3°; United States Magnetic Observatory, 81.7° and 64.6°; W. R. Castle, 60 feet elevation, highest, 79.5°; lowest, 62.5°; mean temperature, 70.4°.

Rainfall data.

Stations.	Elevation.	March, 1902.	Stations.	Elevation.	March, 1902.
HAWAII.			MAUI—*Continued.*	*Feet.*	*Inches.*
HILO, e. and ne.	*Feet.*	*Inches.*	Nahiku (Pogue)	1,600	102.46
Waiakea	50	55.16	Nahiku	800	74.65
Hilo (town)	100	58.57	Haiku, n	700	28.19
Kaumana	1,250	83.83	Kula (Waiakoa)	2,700	14.37
Pepeekeo	100	67.29	Kula (Erehwon), n	4,500	25.64
Hakalau	200	61.84	Puuomalei, n	1,400	40.62
Honohina	300	90.85	Paia, n	180	22.11
Laupahoehoe	500	88.92	Haleakala Ranch, n	2,000	43.91
Ookala	400	94.35	Wailuku, ne	200	12.43
HAMAKUA, ne.			OAHU.		
Kukaiau	250	62.76	Punahou (W. B.), sw	47	11.67
Do	900	73.82	Kulaokahua, sw	50	11.95
Do	1,520	93.39	Makiki Reservoir	120	14.25
Do	3,300	78.30	U. S. Naval Station, sw	6	11.64
Do	5,000	27.01	Kapiolani Park, sw	10	7.84
Paauilo	750	....	Manoa (Woodlawn Dairy), c.	285	25.52
Paauhau (Mill)	300	48.45	School street (Bishop), sw	50	11.31
Paauhau (Greig)	1,150	....	Pacific Heights, sw	700	22.40
Honokaa (Muir)	425	49.24	Insane Asylum, sw	30	13.61
Honokaa (Rickard)	1,900	....	Kamehameha School	75	18.01
Kukuihaele	700	42.61	Kalihi-Uka, sw	260	29.91
KOHALA, n.			Nuuanu (W. W. Hall), sw	50	13.24
Awini Ranch	1,100	....	Nuuanu (Wyllie street), sw.	250	....
Niulii	200	27.43	Nuuanu (Elec. Station), sw	405	21.21
Kohala (Mission)	521	26.09	Nuuanu (Luakaha), c	850	44.25
Kohala (Sugar Co.)	235	21.05	Waimanalo, ne	25	17.06
Hawi Mill	600	28.20	Maunawili, ne	300	15.31
Puuhue Ranch	1,847	30.51	Kaneohe, ne	100	....
Waimea, c	2,720	27.34	Ahuimanu, ne	350	14.51
KONA, W.			Kahuku, n	25	7.90
Kailua	950	....	Waialua, n	20	6.26
Holualoa	1,350	10.17	Wahiawa, c	900	9.81
Kealakekua	1,580	10.17	Ewa Plantation, s	60	7.68
Napoopoo	25	6.85	Waipahu, s	200	9.53
KAU, se.			Moanalua, sw	15	13.59
Kahuku Ranch	1,680	3.89	Magnetic Station	50	6.62
Waiohinu	1,000	10.59	KAUAI.		
Honuapo	15	9.52	Lihue (Grove Farm), e	200	19.79
Naalehu	650	10.31	Lihue (Molokoa), e	300	19.45
Hilea	310	9.00	Lihue (Kukaua), e	1,000	32.50
Pahala	850	....	Kealia, e	15	24.35
Moaula	1,700	....	Kilauea, ne	325	31.95
PUNA, e.			Hanalei, n	10	36.50
Volcano House	4,000	22.21	Waiawa, sw	32	8.15
Olaa	1,690	74.76	Eleele, s	200	....
Olaa (17-mile)	221	....	Wahiawa Mountain, s	2,100	....
Kapoho	110	64.32	McBryde (Residence)	850	29.20
Kalapana, se	8	....	Lawai	450	28.97
MAUI.					
Waiopae Ranch, s	700	....	*Delayed February reports.*		
Kaupo (Mokulau), s	285	34.49	Ookala	......	9.29
Kipahulu, s	300	43.89	Moaula	......	1.30
Hamoa Plantation, se	60	24.28	Kapoho	......	0.43
Nahiku, ne	60	....			

The principal features of the month were the heavy storms which characterized the first and last 10-day periods, with continuous fine weather in most parts during the middle of the month. A northeasterly storm set in on the 27th of February, and was recognized on Hawaii Island as a norther. At the foot of the north slopes of Mauna Kea, Mauna Loa, and Haleakala the rainfall was unparalled; at Kukaiau, Hamakua, Hawaii 1,600 elevation, 62 inches fell in four days, and 82 in eight days.

The storm which set in on the 18th was of similar character, but with less wind and with unusual electrical disturbance. At Luakaha, Nuuanu, 5 miles from the Honolulu post office, 5.55 inches fell in fifty minutes, on the 18th. The heaviest record for the calendar month was 102.46 inches at Nahiku, Maui, at 1,600 feet elevation, which may probably challenge the world's record. Ookala had 94.35 inches. Kukaiau as above 93.39 for the month, and 103 for 33 days, beginning February 27. Other heavy totals will be found in the table of rainfall.

These terrific downpours come with northerly winds following southerly airs which strike the abrupt northern slopes of the islands, so that there is combined the condensation due to the upward movement of the air, with that due to the sudden impact of a cold current upon a nearly stationary mass of warm, moist air surrounding a mountain. Neither of these